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Combined pancreaticoduodenectomy and extended right hemicolectomy: outcomes and indications

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Abstract

Background: Pancreaticoduodenectomy (PD) combined with an *en bloc* extended right hemicolectomy is required to achieve complete oncological resection of various malignancies. Information regarding the indications and outcomes of this procedure is limited.

Study design: Patients requiring PD combined with extended right hemicolectomy for primary tumours from 2002 to 2008 were identified.

Results: PD combined with an *en bloc* extended right hemicolectomy was required in 14 patients, constituting 8% of pancreaticoduodenal resections. Pancreatic adenocarcinoma (8), retroperitoneal sarcoma (2) and colon cancer (2) were the main primary tumours resected. The indication for an extended right hemicolectomy was extensive tumour involvement of the transverse mesentery in seven patients. Clear tumour margins were achieved in 11 individuals. The median operating time was 10 h with intra-operative transfusions required in three patients. One or more complications were noted in eight, with delayed gastric emptying and pancreatic fistula the most common. The median length of hospital stay was 8 days. The overall 2-year survival in this series was 37%, with a median survival of 20 months in pancreatic cancer patients.

Conclusions: This series suggests that PD combined with an *en bloc* extended right hemicolectomy is feasible and can achieve complete tumour clearance with acceptable morbidity.

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Introduction

Pancreaticodudenectomy (PD) is recognized as the optimal method for treating periampullary cancers. While this procedure has been associated with a high mortality in the past, it can be performed safely in high-volume centres with a 1% to 4% mortality rate.[1–4] The duration and complexity of the operation has perhaps caused surgeons to hesitate in undertaking resection when presented with a tumour arising from the periampullary region which has invaded into adjacent organs. Likewise, a tumour arising in the adjacent viscera or retroperitoneum which involves the duodenum or pancreas may cause a similar concern. In the past, these tumours were considered to be unresectable because of the magnitude of the surgical procedure.[5–7] The ques-

tion of resectability of tumours in the scenarios described should be addressed as a locally advanced neoplasm, provided that there is no evidence of metastatic disease or unreconstructable vascular involvement. In particular, pancreatic cancer has a poor prognosis and all attempts should be made at complete surgical resection followed by adjuvant chemoratherapy.[8] Multi-organ involvement of periampullary cancers may be simply a manifestation of disease geography, than aggressive tumour biology. The concept of direct tumour extension has been addressed in several series regarding portomesenteric vein resections and multivisceral resections as part of a pancreaticodudenectomy with excellent surgical results and equivalent survival.[5,9–14]

In this study, we report the results from 14 patients who presented with malignancies which required an *en bloc* resection

including a pancreaticodudenectomy and an extended right hemi-colectomy. Indications, results, complications and technical issues are presented and discussed.

Patient selection and methods

Patients with primary malignancies undergoing PD and extended right hemicolectomy at Penn State Milton S. Hershey Medical Center between January 2002 and March 2008 were identified from a prospectively maintained operative database and their records were reviewed. Internal review board approval was obtained.

Operative details, including indications for combined re-section, the length of procedure, blood loss, complications and long-term outcomes were recorded. All patients undergoing pancreaticoduodenal resection were given mechanical bowel preparations the night prior to surgery unless contraindicated. In all patients, *en bloc* resection of pancreas, duodenum, right colon and portion of the transverse colon was attempted to minimize the risk of tumour disruption, with the aim of negative margins. In patients with a primary colonic malignancy, combined resec-tion was performed when there was significant attachment of the tumour to the duodenum or pancreas, not suitable for a lesser procedure. In other malignancies, the need to perform combined pancreaticoduodenal resection and extended right hemico-lectomy was based on attachment of the tumour to the colon or involvement of the transverse mesocolon, including mesenteric vessels to an extent that mesenteric excision was not considered feasible, without compromising resection margins or colonic blood supply. In no patient was complete resection of the trans-verse colon required.

A lateral to medial mobilization of the right colon, a Cattell–Braasch manoeuver, was initially performed. This involved mo-bilization of the right hemicolon from lateral to medial, with detachment of the root of the small bowel mesentery from retro-peritoneal attachments extending from terminal ileum to the ligament of Trietz. An extended Kocher manoeuver was then per-formed to fully mobilize the duodenum with an effort to palpate a clear plane between any tumour and the pulsation of the supe-rior mesenteric artery (SMA). The gallbladder was then taken in the usual fashion. Next, isolation and retraction of the distal common bile duct and ligation of the gastroduodenal artery was performed. The lesser sac was entered between the embryologic plane between the anterior leaf of the transverse mesocolon and the gastrocolic omentum. A tunnel was created in the plane ante-rior to the portal vein behind the neck of the pancreas. Tumour extension into the colonic mesentery made clear identification of the superior mesenteric vein (SMV) difficult at times. When this occurred, a plane was created at the inferior boarder of the pancreas medial to the expected course of the SMV. This was followed laterally until the SMV was identified. Care was taken to identify and ligate the middle colic vein and gastroepiploic vein adjacent to the SMV to prevent injury to these vessels when

completing the tunnel anterior to the SMV up to the portal vein under the neck of the pancreas.

Once resectability was determined, the stomach was divided in the cases of a classic PD or the first part of the duodenum in cases of a pylorus-preserving PD. Next an extended right hemicolec-tomy was performed with the colon divided in most cases just beyond the mid-transverse colon and a stapled side-to-side, ileo-colic anastomosis performed. A transverse colon resection alone was avoided because of concerns of potentially greater anasto-motic complications and to avoid the need to mobilize the splenic flexure. Mesenteric defects between the colon and ileum were closed. Where the anastomosis was deferred to later in the proce-dure, the ileum and transverse colon were divided with a linear stapling device and the terminal ileum marked with sutures. This was to aid identification of the terminal ileum at the time of reconstruction, as it may be difficult to differentiate from the divided proximal jejunum.

The proximal jejunum was divided approximately 10 to 20 cm from the ligament of Trietz, and the mesenteric vessels ligated close to the intestinal wall. The bile duct was divided at this time, if not performed earlier. The pancreatic neck was then transected across the tunnel previously formed anterior to the portal vein. Portal vein branches arising from the uncinate were identified and ligated. The remaining resection was performed in a standard manner, with the uncinate divided by a combination of tissue coagulation and ligation adjacent to the SMA. Portal vein and superior mesenteric vein resection and reconstruction were performed when appropriate. In all patients, an intra-operative frozen section was performed on the pancreatic and bile duct resection margins, but not on the colonic or mesenteric margins.

In all patients, the proximal jejunum was brought up to the supracolic compartment through the defect created after dividing the ligament of Treitz, in a retro-mesenteric, retrocolic position. Pancreatic, biliary and gastric anastomoses were per-formed in a standard fashion, in the supracolic compartment. An end-to-side, duct to mucosa pancreaticojejunostomy was performed. No pancreatic stents were used. An end-to-side biliary anastomosis was formed using interrupted sutures. A two-layered duodeno-jejunal or gastro-jejunal anastomosis was formed. Abdominal drains were placed adjacent to the biliary and pancreatic anastomoses. A feeding jejunostomy was utilized in severely malnourished patients. Complications were defined according to previously defined criteria.[4] A pancreatic fistula was defined as an amylase drain fluid level greater than three times the serum value measuring 30 mL or more on or after day 5 post-operatively. Octreotide was not administered in this series. Erythromycin was commenced at day 2 post-operatively at a dose of 200 mg intravenously every 8 h for reduction of the risk of delayed gastric emptying until the time of hospital discharge.

Results were expressed as median (range) unless otherwise stated. Survival analysis was performed using the Kaplan–Meier

limit method to determine overall survival after PD using a statistical software package (Version 11.5; SPSS Inc., Chicago, IL, USA).

Results

During the study period, a total of 180 patients underwent pancreaticoduodenal resection. A combined pancreaticoduodenal resection and extended right hemicolectomy was performed in 14 (8%) during this time with the details of each patient noted in Table 1. There were nine male and five female patients. The median age at the time of surgery was 65 (50–85) years. The primary tumours treated included eight pancreatic adenocarcinoma, two retroperitoneal sarcoma, two primary colon cancer, one duodenal gastrointestinal stromal tumour (GIST) and one duodenal adenocarcinoma. In seven patients, the indication for an extended right hemicolectomy was extensive tumour involvement of the transverse mesentery. In three patients, there was attachment of the tumour to the colon. In one patient, there was direct colonic wall infiltration by the tumor. An inflammatory reaction in the transverse colon was noted in one further patient, for whom neoadjuvant chemoradiotherapy was administered for locally advanced pancreatic cancer. An SMV resection and reconstruction was performed in this instance. There were two patients with colon cancer with direct extension of tumour into the pancreas/duodenum, requiring this combined procedure. After intra-operative discovery of colon cancer infiltration into the duodenum, one of these patients was transferred to our service from an outside institution. In the remaining patient with colon cancer, there was pre-operative suspicion of peripancreatic tumour infiltration on imaging tests.

The median operating time was 10 (8.5–20.5) hours. Median estimated blood loss was 525 (100–2150) mL. Intra-operative blood transfusions were required in three cases. Overall operative or post-operative blood transfusions were required in eight cases. One or more complications were noted in eight cases, with delayed gastric empting being the most common (four) and a pancreatic fistula occurring in two cases. Median post-operative intensive care stay was 1 (1–5) day. Median length of post-operative hospital stay was 8 (6–19) days. Microscopic positive margins were reported on histology in three cases. Two patients with pancreatic adenocarcinoma had positive uncinate margins on histology. One patient with a large colon tumour had microscopic involvement of the colon mesentery adjacent to the superior mesenteric vessels. Median follow-up in this series was 15 (5–41) months. During this period, there were five deaths in patients with pancreatic cancer related to disease recurrence. At the last follow-up, two out of 14 patients required pancreatic enzyme supplements. One of these patients had persistent diarrhoea despite pancreatic enzyme supplementation. The overall 2-year survival in this series was 37%. The median survival of the eight patients with pancreatic cancer was 20 months.

Discussion

The mortality rate associated with PD has decreased dramatically in recent years and approaches zero per cent in high volume centres.[15–17] With these improvements, there has been an increasing willingness to expand the indications for PD and also the extent of resection. Traditionally, direct tumour extension outside of the pancreas, invasion into adjoining organs, invasion into the transverse colon or its mesentery and major vascular encasement, either partial or complete, were criteria for unresectability.[5–7] There are numerous reports of good long-term outcomes after portal vein resection, when complete tumour clearance is obtained.[10,14,18,19] Similarly, invasion of periampullary cancer into the transverse colon or its mesentery may be treated using combined PD and extended right hemicolectomy to achieve tumour clearance.[9,20]

PD combined with extended right hemicolectomy should only be entertained when there is no other method to achieve complete resection. When a tumour arises from the periampullary region, we attempt to avoid combined resection unless it is absolutely necessary. In the majority of cases, a simple excision of a portion of the transverse colonic mesentery, including the middle colic vessels or its branches, allows tumour clearance. We performed a combined PD and extended right hemicolectomy when extensive excision of the colon mesentery and accompanying vessels was thought to compromise colon viability, in cases of direct invasion into or from the colon, and when complete tumour clearance was in question without a combined organ resection. In half of our cases, extensive tumour involvement of the transverse mesocolon was the indication for combined resection. In cases of extra-pancreatic tumour attachment to the duodenal wall, partial duodenal wall resection and repair is considered, except when there is extensive duodenal involvement, pancreatic invasion or when the tumour encroaches on the ampulla of Vater.

There are several technical points which should be considered when performing combined *en bloc* resection. A serious potential pitfall may arise after the proximal jejunum and the distal ileum are transected. If not properly marked with identifying sutures, the orientation of the bowel may become indistinct, leading to uncertainty as to which end is proximal or distal. This obviously has serious implications and should be addressed as such. We often complete the colonic resection and ileocolonic anastomosis before transecting the proximal jejunum to ensure that this is not in question. After a pancreaticodudenectomy, reconstruction may be achieved in several ways. We usually advance the proximal jejunum in a retrocolic fashion in a convenient area through the transverse mesocolon. This may still be performed, but the wide Cattell–Braasch manoeuver and complete division of the Ligament of Treitz, allowing for the proximal jejunum to be passed under the superior mesenteric vessels, in essentially the same area that the duodenum normally occupies. This is purely a technical detail and we do not believe that it provides any functional benefit. In our study, the median operating time was 10 h, reflecting the complex nature of the cases treated.

Table 1 Characteristics of patients undergoing combined pancreaticoduodenal resection and right hemicolectomy

Patient No.	Age	Sex ASA	Malignancy	Staging (TNM)	Colon status	Resection	Peri-operative course (EBL, blood transfusion, operative time, LOS)	Complication	Chemotherapy/ radiotherapy	Outcome
1	63	F III	Pancreatic Adenocarinoma	Stage III T2N1M0	Invading mesentery	PPPD, Right Hemicolectomy R1 Uncinate involved	100 mL,0 units, 9.5 h, 7 days	None	Adjuvant Gemcitabine Radiotherapy	Alive Disease Free 19 months
2	67	M III	Pancreatic Adenocarinoma	Stage III T1N1M0	Invading mesentery	Classic PD, Right Hemicolectomy R0	1000 mL, 0 units, 10 h, 7 days	None	Adjuvant Gemcitabine Radiotherapy	Deceased 22 months
3	85	M IV	Pancreatic Adenocarinoma	Stage III T2N1MO	Invading mesentery	PDD, Right Hemicolectomy, FJ, R0	500 mL, 2 units, 10 h, 7 days	None	None	Deceased 16 months
4	50	M II	Duodenal GIST	7 cm tumor Mitoses 5/50 hpf	Attached to colon	PPPD, Right Hemicolectomy, Excision of mass, R0	600 mL, 0 units, 8.5 h, 8 days	None	Adjuvant Imatinib Mesylate	Alive Disease free 41 months
5	56	M III	Retroperitoneal Liposarcoma	20 cm tumor T2N0M0 G1	Attached to colon	Classic PD, Right hemicolectomy, right nephrectomy, R0	900 mL, 2 units, 15.5 h, 7 days	Delayed gastric emptying, Ileus, Intra-abdominal collection	None	Alive Disease Free 20 months (Re-operation for recurrence at 18 months)
6	64	F III	Pancreatic Adenocarinoma	Stage III T3N1M0	Invading mesentery	Classic PD, Right hemicolectomy R1 Uncinate involved	400 mL, 0 units, 15.5 h, 13 days	Pulmonary Emboli	Adjuvant Gemcitabine Radiotherapy	Deceased 13 months
7	83	F III	Pancreatic Adenocarinoma	Stage IVA T4N1M0	Colon infiltration	Classic PD, Right Hemicolectomy, FJ, R0	500 mL, 2 units, 11 h, 16 days	Cardiac Arrhythmia, Wound infection	Adjuvant Gemcitabine and Erlotinib	Deceased 5 months
8	76	F III	Pancreatic Adenocarinoma	Stage III T3N1M0	Invading mesentery	PPPD, Right Hemicolectomy R0	550 mL, 8 units, 10.5 h, 14 days	Post operative Hemorrhage	None	Deceased 20 months
9	65	F II	Pancreatic Adenocarinoma	Stage I T1N0M0	Inflammatory Reaction mesentery	PPPD, Right Hemicolectomy, SMV resection, R0	200 mL, 0 units, 9 h.	None	Neoadjuvant Gemcitabine radiotherpay	Alive Disease Free 11 months
10	71	M IV	Colon Adenocarcinoma	Stage III T4N1M0	Invading pancreas	PPPD, right Hemicolectomy R1 – Root of Mesentry	750 mL, 2 units, 8.5 h, 19 days	Delayed gastric Emptying,	FOLFOX/ Bevacizumab	Alive Recurrence Metastases 27 months
11	64	M III	Pancreatic Adenocarinoma	Stage III T3N1M0	Invading mesentery	Classic PD, right hemicolectomy R0	720 mL, 2 units, 15.5 h, 7 days	Delayed gastric emptying	Adjuvant Gemcitabine and radiotherapy	Alive Disease Free 9 months
12	64	M III	Duodenal Adenocarinoma	Stage III T4N1M0	Invading mesentery	Classic PD, right hemicolectomy R0	400 mL, 2 units, 10 h, 7 days	None	FOLFOX Radiotherapy	Alive Recurrence Metastases 11 months
13	61	M III	Retroperitoneal Liposarcoma	24 cm tumor T2N0M0 G3	Attached to colon	Classic PD, right hemicolectomy, right nephrectomy and adrenalectomy, excision of mass R0	2150 mL, 4 units, 20.5 h, 10 days	Grade A Pancreatic fistula	None	Alive Disease Free 9 months
14	83	M IV	Colon Adenocarcinoma	Stage III T4N1M0	Invading duodenum	Classic PD,right hemicolectomy R0	100 mL, 2 units, 8.5 h, 12 days	Grade A Pancreatic fistula, Delayed gastric emptying	None	Alive Disease Free 12 months

ASA, American Society of Anesthesiologist score; TNM, tumor node metastases grading; G, histologic grade; PPPD, Pylorus preserving pancreaticoduodenectomy; PD, Pancreaticoduodenctomy; FJ, Feeding jejunostomy; R, Resection status; GIST, Gastrointestinal stromal tumor; EBL, Estimated blood loss; LOS, length of stay (post-operative); FOLFOX, Folinic acid, Fluorouracil, Oxaliplatin; hpf, high power field.

The previously largest series of PD combined with extended right hemicolectomy was a Japanese series of 12 cases from a total of 104 pancreaticoduodenal resections (12%).[9] The median overall survival of patients treated by combined resection in that series was 14 months and the end of follow-up. In another Japanese study, 12 patients with advanced colon cancer underwent combined PD and extended right hemicolectomy representing less than 0.5% of patients undergoing colon resection in that institution.[20] In that series, the overall survival of patients with colon cancer was similar to staged matched patients not requiring PD in other reports.[21,22]

In our series, 14 patients underwent combined PD and extended right hemicolectomy, which is the largest series report to date. These operations were, however, performed for various primary malignancies rather than a single pathology. The most common indication for surgery was locally advanced pancreatic cancer in 8 out of 14 patients. The median survival of the eight patients was 20 months and is comparable to staged matched patients treated by PD alone and appreciably better than unresected patients.[4,14,23] During the study period, the overall PD combined with extended right hemicolectomy represented 8% of PD resections. Although this is similar to the report by Suzuki *et al.*,[9] it is higher than would be expected based on reports from other high-volume centres. The high proportion of PD combined with extended right hemicolectomy may be related to our interest in the management of complex pancreatic disorders and a high volume of referrals of patients with retroperitoneal sarcomas and advanced GISTs. Despite the complexity of some of the cases performed, the observed complications were generally of low clinical impact with a median length of hospital stay of 8 days. There was no complication directly related to right hemicolectomy.

PD with an *en bloc* extended right hemicolectomy is technically feasible with the major indications being pancreatic malignancy, colon cancer and retroperitoneal sarcoma. Combined resection often achieves a negative surgical margin, has a similar complication rate to PD alone and does not appear to prolong hospital stay. Patients with pancreatic cancer appear to have similar survival to those undergoing PD alone and improved compared with unresected patients. In cases of periampullary cancers, involvement of the colon or transverse mesentery should be considered a manifestation of disease geography rather than advanced tumour biology. Although further evaluation of this procedure is warranted, we believe that this aggressive approach is a safe and effective extension of PD when performed by experienced surgeons in high-volume centres.

Conflicts of interest

None declared.

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